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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. X. BOSTON, MASS., JUNE, 1893. No. 2.

NEW ENGLAND METEOROLOGICAL SOCIETY.

THE Twenty-seventh Regular Meeting of the New England Meteorological Society was held on April 22, 1893, in the Geographical Laboratory of Harvard University, Cambridge, Mass. Papers were read as follows: The Relation of Solar Spots to Terrestrial Anticyclones, by Prof. Arthur Searle, of the Harvard College Observatory; A New Series of Isanomalous Temperature Charts, based on Buchan's Isothermal Charts, by S. F. Batchelder; Oscillations of Lakes (Seiches) in Europe and America, by E. B. Perkins; Relation of the Prevailing Winds to the Physical Features of Missouri, by W. W. Clendenin. A general discussion on Proposed Subjects for Correlated Study by State Weather Services was opened by Prof. W. M. Davis, who also made a statement of the work of the late H. F. Blanford.

The papers by Prof. Searle, Mr. Batchelder, Mr. Clendenin and Prof. Davis are here published. Mr. H. H. Clayton was prevented by sickness from presenting his paper on Cloud Movements in Cyclones and Anticyclones, which will shortly appear in this JOURNAL.

NOTE ON THE RELATION OF SOLAR SPOTS TO TERRESTRIAL ANTICYCLONES.

PROF. ARTHUR SEARLE, HARVARD COLLEGE OBSERVATORY.

IT must not be supposed that the relation now to be considered is a relation of cause and effect. It is simply an analogy, recently suggested in the *Astronomische Nachrichten* (Vol. 132, p. 17), by Egon von Oppolzer. The phenomena of solar spots have been occasionally compared with those of terrestrial

cyclones by previous inquirers; but Oppolzer's idea of substituting the anticyclone for the cyclone, as the terrestrial term of the comparison, seems both striking and plausible. It is now usual to regard an anticyclone as an atmospheric region chiefly occupied by a descending current of air, which, in a previous ascent, has freed itself from watery vapor by condensation due to its own expansion. In its descent, accordingly, its own recovery of density acts with full effect in raising its temperature, and it dissipates any clouds which it may encounter, thus permitting unobstructed radiation from the ground beneath. The warm air fails to reach the surface which it has exposed to this radiation, and which consequently chills the air immediately in contact with it, while the warmer air above flows off laterally.

Similarly, an ascending current in the solar atmosphere may be regarded as freeing itself from the heavier metallic vapors which it originally contained, and as having the capacity on its subsequent descent to dissolve the precipitated vapors which it first encounters. A cavity, more or less funnel-shaped, will thus be formed in the photosphere, the lower portions of which will be exposed to unusually free radiation, probably sufficient to diminish its temperature and its luminosity, and accordingly to form the umbra of a spot. The penumbra will be constituted by higher regions of the cavity where the dispersion is less complete and the radiation less active. A moderately sharp boundary between the umbra and the penumbra is fairly in accordance with such terrestrial phenomena as a well-defined mass of mist in a mountain valley. This point, however, is not discussed by Oppolzer in the article above mentioned. His object is rather to explain the varying rotation of the sun, as derived from observation of solar spots in different latitudes, as well as the most prominent phenomena connected with the first appearance of spots in high latitudes after a minimum, and the final approach to the solar equator, towards the end of a cycle of activity, of the regions where spots originate. For this purpose he supposes periodical outbreaks of ascending currents near the poles which move spirally for a longer or shorter time and finally return to the solar surface. The details of this supposed process do not strictly belong to the analogy which has here been explained.

Prof. Davis remarked that the comparison drawn by Oppolzer should be limited to terrestrial anticyclones during the long nights of winter; for in the long days of summer the ground under an anticyclone becomes unduly heated, instead of being cooled. The sun is in the condition of a permanent terrestrial night, as far as the relations of received and emitted radiation are concerned.

If we assume that the luminosity of the solar surface is proportionate to its temperature, then Oppolzer's theory does not give a clear reason for the relative darkness of the umbra of a spot. By analogy with terrestrial conditions, where the upper clouds of a cyclone are certainly as cold as the earth's surface beneath an anticyclone, we should not expect the bottom of a solar spot to be colder than the outer surface of the surrounding cloudy photosphere. It is, therefore, necessary to make an additional supposition concerning solar luminosity; namely, that it varies not only with the temperature but also with the constitution of solar substance; and that while the relatively cold cloudy surface of the photosphere is extremely luminous, the hotter umbra of a spot, at a level far below the photosphere surface, is really hotter, and appears darker only because of its gaseous constitution, whereby its radiating power is reduced. The umbra of a spot may therefore be simply a glimpse of a very hot gaseous interior of the sun revealed where a descending anticyclonic current dissolves the cloudy photospheric shell, and not of a cooled solar surface locally revealed beneath a cloudy atmosphere.

A NEW SERIES OF ISANOMALOUS TEMPERATURE CHARTS, BASED ON BUCHAN'S ISOTHERMAL CHARTS.

S. F. BATCHELDER.

THE irregularities in the distribution of heat over the globe offer a subject of peculiar interest. By the laws of the solar climate, or the sun's rays acting on a globe of uniform surface, the temperature should decrease steadily from equator to either pole, as the obliquity of the sun's rays increases; and on every parallel of latitude the mean temperature should be the same at every longitude. As a matter of fact, however, we find the most astonishing departures from this rule. The

parallel of 70° N. latitude, to take a striking example, is at one point 3° F. too warm for the mean temperature of the circle, and at another point 17° too cold.

Discrepancies in the temperatures of different points on the same parallel were first called to prominent notice by Baron Von Humboldt in 1817. At that date the number of stations where thermometric observations were taken was so small that, for lack of data, he could do no more than indicate a few cases where stations had a temperature above or below the average of their latitude.

In 1852 Heinrich Wilhelm Dove published his "Distribution of Heat over the Surface of the Globe." This work contained charts dedicated to Humboldt, embodying his idea under the name of Thermic Isabnormals, or lines of equal departure from the normal or mean temperature of each parallel. From the greatly increased number and accuracy of thermometric observations in his day, Dove was enabled to construct charts that are still approximately correct; but from the latest authority on the subject of terrestrial surface temperatures, Dr. Alexander Buchan of Edinburgh, by whom the observations of the *Challenger* Expedition have been reduced, I have constructed a new set of isabnormal, or more properly, isanomalous, charts that show more plainly than ever the frequent enormous departures from the average temperature of a parallel of latitude.

The most noteworthy cases in which these new charts emphasize the facts given by Dove, are those in which the normal temperature of the latitude is interfered with in places by the thermic influences of the ocean currents. The Antarctic current, for example, that flows up the west coast of South America, has long been known to lower the temperature of that region below what we should expect. Dove found the most pronounced "too cool" area here to be 6.7° F lower than the average of its latitude; I have found it to be 10° too cool. The similar too-cool area on the west coast of Africa, Dove gives as 4.5°; I obtain it as 6°. A point of especial interest regarding this west African cool area is its position as I have been able to place it. Dove and others have located it nearly in the *centre* of the South Atlantic, where it is more or less unaccountable for; I have located it close to the east edge of the ocean-basin, where it strikingly verifies the theory of the ocean eddies, the cold Ant-

arctic water being brought up in the left-handed current of this ocean. The unexpected warmness of Southern Alaska, due to the North Pacific eddy, is given by Dove as +6.7°; by my chart it is +10°. The north coast of Norway, again, under the influence of the Gulf Stream, rises to the great excess of +23° over the average for its latitude, as against 20.3° of Dove.

The cold areas in the interior of North America and Asia, given as —11.3° by Dove, are now shown to be —14° from the mean temperature of their latitude.

In the first charts which I constructed I followed Dove's plan of connecting the normal points of each parallel, those on which the temperature is neither too high nor too low for the mean, by a *line*. Finding the impossibility, however, of indicating in this manner whole areas, as the large belt in the South Pacific, where the temperature is normal throughout, I adopted in my last chart the plan of including all points of *no* departure, together with those whose departures were not more than + .° or —2° in a *belt*, the belt of (approximately) normal temperature. The main results of my work, at a later date, I hope to embody in a fuller paper upon this interesting subject.

THE RELATION OF THE PREVAILING WINDS TO THE PHYSICAL FEATURES OF MISSOURI.

W. W. CLENDENIN.

THE prevailing winds of a region are determined mainly by three things: its latitude, its location with respect to large bodies of land and water and its local topography; or, as we may say, are dependent upon terrestrial, continental, and topographic conditions. No single condition alone will satisfactorily account for either direction or constancy of the winds of any section, especially if that section be intra-continental or one of strong relief.

But if no one of the named conditions is sufficient to explain the direction of the prevailing winds, so none may be omitted. It is readily granted that *strong* continental relief exercises great influence upon the winds, but it is not so generally observed that even comparatively faint relief may also be effective.

In considering the relation of the winds to the topography of

Missouri, it is thought the influence of even weakly developed topographic forms may be shown.

In latitude, Missouri is situated in the great belt of southwesterly winds, and should, if there were no interrupting elements, have prevailing southwest winds. An examination of the weather charts and tables compiled from eighteen years' observations, shows not only that such winds do not generally occur, but also that no station in the State has its prevailing wind from the same quarter at the different seasons ; and furthermore, the direction of the prevailing wind at different stations in the same season is different. For example, at St. Louis the northwest and south winds are about evenly balanced for the first three months of the year, and the same is true of Kansas City. For the same time, in northeastern Missouri, the northerly winds prevail, while in southwestern Missouri the southerly are most frequent. For the rest of the year, the prevailing winds are from varying southerly quarters for all parts of the State. This general scheme seems to be the result of the southerly winter and northerly summer migration of the great continental low pressure areas that move across the country, Missouri lying near the average southern winter limit. Analyzed more minutely it will be seen that this general continental effect is greatly modified by local topography. It has been observed that stations to the south of the Ozark Mountains, which rise gradually from the north, and in no place attain an altitude of two thousand feet, are protected from the severe cold waves common in north Missouri, but which as a rule do not pass up the Ozark slope. On the other hand, points north of the Ozarks escape the hot southern summer winds common south of them. At St. Louis the wind is generally up or down the Mississippi Valley or down the Missouri valley, southwest winds being rare. At Springfield, in southwestern Missouri, the same interruption, the Ozarks, prevents southeast winds, and the southwest are the prevailing winds. At Kansas City, while the prevailing winds follow the Missouri valley, the broad level plain to the south and west offers no obstacle to winds from those quarters.

Perhaps the most striking effect of local topography upon prevailing winds is seen at Fort Smith, Ark., in the valley of the Arkansas River. Protected both north and south by spurs

of the Ozarks, the winds following the valley of the Arkansas River, are throughout the year prevailingly east. It would thus seem that winds of summer, sweeping up from the Gulf region by way of the Mississippi valley, dragging and lagging along the sides, when they reach southeastern Missouri or northern Arkansas, where the Ozark Mountains begin, rise and are divided, part continuing up the Mississippi valley, and part being deflected by way of the Arkansas River to the west. As a consequence, St. Louis and river points south of it have southerly winds, while Fort Smith and points on the southern slope of the Ozarks have easterlies and southeasterlies. West of Fort Smith these easterlies are joined by much stronger, uninterrupted southwesterlies, which give character to the winds of southwestern Missouri, producing southwesterlies. These, spreading fan-like along the northern slope of the Ozarks, determine the prevailing winds at stations south of the Missouri River. About St. Louis the south and southeast winds are in part deflected by way of the Missouri valley to the northwest, while the remaining weakened part continues up the Mississippi valley, and in northeastern Missouri is still felt as a somewhat frequent south and southeast wind. The part shunted by the Missouri River valley is joined by the southwest winds that have passed up west of the Ozarks, and together they continue up the Missouri valley and less freely spread over the entire northern part of the State as variable south and southwest winds. The farther west we go the weaker becomes the southeast element, and at Kansas City and Leavenworth, Kan., the south winds prevail. It would, therefore, seem that the prevailing winds of south and southeast Missouri are chiefly controlled by the Mississippi valley and the Ozark Mountains; that southwest Missouri receives, but little disturbed, the southwesterlies that sweep across the plains of Texas and Indian Territory; that the southeasterlies across western Tennessee and Kentucky unite with the body of air ascending the Mississippi valley and give to eastern and northeastern Missouri prevailing south and southeast winds, while the winds of north and northwest Missouri are determined by the varying comparative strengths of south and southwest winds sweeping directly across Texas, Indian Territory, and Kansas, and the southeast winds ascending the Missouri valley; all, however, but local

modifications of the inflowing currents to the great prevailing summer "low" in the northwest. In winter the conditions are changed. The area of low pressure has migrated southward and the Saskatchawan region is now one of high pressure, out from which the winds flow. Those to the south find little interruption in moving down the gently sloping country to the south until the Missouri River valley is reached, when they are deflected, and reach Missouri as northwest winds. The controlling effect of the valleys of the Missouri and Mississippi rivers is of the same value, but reversed in direction. The same is true of the Ozarks, though their influence is perhaps of less value than in summer because of the strong western element due to winds sinking down the eastern slopes of the Rocky Mountains, thus giving to southwestern Missouri frequent westerlies.

It would appear, therefore, that the Ozark Mountains and the valleys of the Mississippi and Missouri rivers are very effective in determining the direction of the prevailing wind of any section of Missouri; also that it is the influence of the broad valley, rather than that of the narrow trench in which the river runs, that is felt.

I do not doubt that further observations will show that even the valleys of the larger tributary streams, the Osage, the Gasconade and the Grand, have a distinctly noticeable effect upon the winds. At present there are no records upon this point.

So far as the winds of Missouri are concerned, therefore, the conclusion seems to be that while unquestionably influenced by terrestrial conditions of latitude, etc., their *general* direction is much more largely the effect of continental conditions, determining the relative positions of low and high pressure areas; and their *local* direction the result of the directing power of even moderate topographic relief.

PROPOSED SUBJECTS FOR CORRELATED STUDY BY STATE WEATHER SERVICES.

PROF. W. M. DAVIS.

SINCE the transfer of the Weather Bureau to the Department of Agriculture, the State weather services have gained even on their development in previous years, and they are now estab-

lished in every State and Territory, except Alaska. All of these services, with the exception of Idaho, issue a monthly report in some form. Voluminous records are thus accumulating; but for the most part, they deal with climatic data; and the title of weather services is therefore a misnomer. In due time, if the records are steadily maintained, they will yield results of much value in the determination of climatic provinces, and in the construction of climatic maps; the chief difficulty in this regard being to secure the use of accurate instruments, well exposed, and regularly and continuously recorded for a sufficient interval. This work is now in progress, under as favorable conditions as it is likely to encounter for some years to come. But there is another aspect of the work that is open to State weather services to which I wish to call attention; and the present time is auspicious for my suggestion, inasmuch as an association of State weather services was formed last summer, and its proceedings have lately been published as Bulletin 7, of the Weather Bureau.

The State services now possess a large body of observers, numbering over two thousand, and including many persons well fitted for co-operative investigations, and many who would be interested in such undertakings. It appears to me unfortunate that such a body of observers should not attempt from time to time, something more than the routine observations to which their attention is now so largely restricted. Their records are now reduced almost entirely in an arithmetical manner, such as is fitting for the determination of climatic quantities, but which does not suffice for the determination of unperiodic factors, of the kind with which weather changes are concerned. The observers are thus, as it were, held down to routine work, instead of being encouraged to expand their studies in new directions. The routine work must, of course, be continued; and it is too much, at present, to expect that original methods of reduction of local observations should be attempted in such form that the features of the weather, as well as of the climate, shall be defined; but it does not seem to me beyond reasonable possibilities for us to look for some extension of observations into new directions, from which new results might be gained.

Some years ago, I called attention to a plan of co-operative observation, by which useful and novel results might be obtained.*

* This JOURNAL, I., 1884, 155.

I daresay the plan is old; it is not its novelty but its usefulness that tempts me to bring it forward again. It involves the announcement from the central office at Washington of certain days on which all observers would be requested to make *hourly records of the ordinary weather elements*, with as full a descriptive account of the phenomena observed as possible. The observations would then be gathered at the central office of the State service, and charted on sheets of uniform scale for every hour; these sheets would be sent to Washington, and there consolidated on a single map of the whole country. I believe that some extremely interesting illustrations of weather phenomena would thus be gained; and that they might serve in certain cases to give us juster understanding of processes now imperfectly understood. The successive steps of the plan are in brief as follows: —

The plan should be fathered by the National Weather Bureau; for no other organization has force enough to carry it through, and with no other is it so properly and naturally associated. An announcement of its method and objects must be made for wide publication in the newspapers. The area embraced in the first season might be limited westward by the Rocky Mountains. All voluntary observers now on the lists would be addressed by special circular. Numerous additional observers should be enlisted for this particular object. All applicants should be furnished with brief instructions concerning the simple duties expected of them, and with an enlistment card. Those who felt that they could do the required work would signify their intention by signing the enlistment card, underneath a brief, printed statement of the character of the observations expected; and their trustworthiness and their signature would be certified to by the signature of the local postmaster, school-teacher, or other person of public position and responsibility. In New York, Ohio, and Pennsylvania, a thousand observers in each State might be reasonably expected.

After the announcement of the plan and the execution of its first step, and without waiting too long to tire the patience of the newly enlisted observers, the weather maps at the central office should be watched until the approach of some particular atmospheric phenomenon is indicated in the western districts; then a general notice should be distributed along with the

announcement of the daily forecasts, specifying a certain date as the one selected for hourly observations. It might be called "First day of general observations." Some of the observers would accidentally overlook it; but the greater number would learn of it in season to make their records. These would be, as stated above, hourly records of temperature, wind, cloudiness, and rainfall; and as full a running record of the events of the day as the observer could secure. There would be a great difference in the accuracy and completeness of these records; uniformity cannot be reached and need not be attempted. Every observer would be expected to do his best; the fuller records would aid in the interpretation of their less complete neighbors. At the close of the day, all records would be mailed to the office of the State service.

I should expect to find numerous teachers, scholars, doctors, tradesmen, mechanics, farmers, and intelligent citizens generally, women as well as men, taking as full a part in this national work as they could. It might arouse a wide-spread interest. Many a person who could not give time for regular observations through the year, might, on occasions like this, spare intervals of a day to make records every hour. Many a record would be the product of several observers at a single station, each one supplementing the others in turn. The work would direct renewed attention to the State services, to the national service, and to the science in which they are both engaged. It might likely enough incite many persons to regular observations. Such was the result when our Society some years ago carried on its studies of thunder-storms and sea-breezes; but from being short-handed, we failed in one respect where a larger organization would succeed; we were unable to make a sufficiently prompt return to our observers, and thus maintain and cultivate their interest by sending them bulletins of general results while the local facts were yet fresh in their memories.

On the receipt of the records at the offices of the State weather services, such maps as those issued by the Post Office department might be used for charting. A sheet of tracing paper laid upon the map would suffice to receive the observations; and thus a single base-map would serve for the charting of the whole series of hourly records. Perhaps two tracings would be needed for each hour; but experience would soon

determine this. After entering the temperatures, winds, clouds, rainfall, etc., lines world be drawn to exhibit the distribution of these weather elements; and when a satisfactory series of charts had been produced, the results would be transferred to maps of smaller scale, such as that of the nine-sheet contoured map of the United States, recently prepared by the United States Geological Survey. Here again, if economy is needed, the lines of temperature, wind, etc., for each hour might be entered on sheets of tracing paper, instead of on the engraved map; and these small-scale reductions of the originals would then be sent to Washington.

Less time would be needed for the general assemblage of the State sheets than for their preparation. Within two months of the date of observation, a preliminary statement of the results, with illustration on a series of maps on the scale of the daily weather map, might be prepared and distributed over the country. Fuller discussion of the results would follow more deliberately. The individual observations would, of course, be omitted on all but the first series of large-scale maps. The lines drawn from the original observations would alone appear on the series of smaller-scale maps; and a generalization of these lines would alone be published on the series of smallest-scale maps. Any one who has attempted to draw isotherms, wind lines, cloud areas, and other similar features, will recall his continual need of more facts; and this need would be in great part supplied by the records of numerous volunteer observers. Every one who has attempted to trace the progress of our weather phenomena across the country has felt the need of more frequent hours of observation, for the purpose of accurately defining the succession of changes by which the features of one map are transformed and transplanted into those of another. This need would be in great part satisfied by the records from many observers at successive hours.

The most interesting kind of a day for general observations would be one on which a cyclonic centre lay in Iowa in the morning of a spring or early summer month, and progressed eastward towards night. A great volume of unduly warm, moist, cloudy, and rainy air is drawn northward from the Gulf in front of such a cyclonic centre, looping the isotherms forward in its course. Another great volume of cool, dry, and clear air comes

sweeping across the plains from beyond our northern border in the rear of the cyclonic centre. There has been much speculation as to the phenomena produced along the line where the most abrupt transition is made between these two winds; and this speculation would be profitably limited by a series of hourly charts, compiled from the records of numerous observers. One of the particular questions that I hope to see answered in this way is the relation of local storms to the area of southerly winds. It now appears that some of these storms spring up within this area, some distance eastward from the line where the most rapid fall of temperature is determined by the advance of the cooler westerly winds. Other storms occur close along this line, and are evidently related to the contrasts by which it is characterized. Still others, especially in the later summer months, are found some distance to the west of the dividing line, and are entirely included in the area of westerly or northwesterly winds. It is useful even now to theorize upon the different conditions by which these several sub-classes of local storms are determined; but the theorizing would be better if it had a larger number of well-ascertained facts for its support. It is by no means random theorizing even at present, but its conclusions would be strengthened if the conditions that are now more or less hypothetical were then directly determined by observation.

The days selected for general observation should not, of course, be limited to times of sirocco-like winds and expected local storms; study should be made of various other conditions of cold or warm waves, of backing winds on the north of cyclonic centres, and of anticyclonic calms in winter and summer, and especially of those vague nondescripts of weak, irregular gradients, whose processes are little known. We should have, under a general eastward gradient, for example, a great sweep of northwesterly winds; and by charting them, we should gain a good idea of the effect of our moderate topographic features upon their line of flow. We know little of that interesting subject at present; not that winds are not seen here and there to depart from their expected course with relation to the gradient, and from the direction of their fellows at neighboring stations, but that such departures are so isolated and disconnected from other records that we cannot surely determine their cause.

The expense attendant upon the work required in carrying

out this plan is probably the greatest obstacle in the way of its accomplishment; but there is opportunely an announcement made of a great fund for meteorological research, lately given by Mr. Hodgkins into the hands of the Smithsonian Institution, and presumably available for such a study as this. If the plan were heartily taken up by the national and the State services, broadly announced to the people, and liberally supported by the Hodgkins fund, I think it would result in giving us pictures and histories of weather changes almost as much in advance of those now presented on our weather maps as these are in advance of the local records of ancient meteorological times.

NOTICE OF H. F. BLANFORD.

PROF. W. M. DAVIS.

MR. PRESIDENT: Those of us who have studied the rich productions of the meteorological service of India will join in sincere regrets at the news of the recent death of Henry F. Blanford, which occurred in England on January 23, 1893.

Mr. Blanford took a leading place among meteorologists by his labors in the development of the Meteorological Department of India, established in 1875. Much work had been done in that great peninsula before his time: Piddington had investigated the cyclones of the Indian seas; Chambers had published an elaborate account of the meteorology of Bombay; Wilson and others had begun a series of cyclone memoirs; and various meteorological stations were established; but these were relatively independent and unsystematic in their work. Under Mr. Blanford, uniform equipment and methods were introduced, and as a result we now possess, as Blanford himself had the satisfaction of seeing, "a far better knowledge of the weather and climate of India than of those of any other tropical country, and, in some respects, better than those of many parts of Europe."

Mr. Blanford's imprint on all this work is strong and clear. In the text-book of meteorology, published in Calcutta under the title of the "Indian Meteorologist's *Vade-mecum*," for the instruction of his observers, we find a better presentation of the facts of the modern science than nas appeared in any book in

England. It shows that meteorology is more than climatology, more than a simple arithmetical treatment of routine observations. It deals with processes carried on in the great physical laboratory of Nature. The relation of local facts of observation to the greater processes to which they belong is admirably brought out in the "*Vade-mecum*." In the annual volumes of Records, we have a superb series of data on a most interesting tropical country; we are confident that they embrace accurate observations, thoroughly discussed and elaborately published. In the Memoirs, there is an almost unrivalled series of investigations, — by Blanford himself, as well as by Eliot, now in charge of the department since the retirement of Blanford to England, Hill, whose untimely death came two years ago, and others. Associated with these are the atlases of the Indian seas, our best source of information on the currents, winds, and temperatures of those equatorial regions. For over a decade there have been daily weather maps prepared, on which we find illustration of not only the more violent cyclones moving northwestward in the transition periods, but also those interesting cyclonic storms of less energy in the winter season, moving eastward over northern India, and producing on the edge of the torrid zone all the sequence of weather changes which we experience here in the middle of the temperate zone. Examples of these are presented in that most attractive work, the latest volume by Blanford, on the "Climates and Weather of India," an invaluable work of reference. Mention should not be omitted of a little text-book for use in Indian schools, on the rudiments of the "Physical Geography of India," from which we see that its author had a lively appreciation of geographical features, as well as of atmospheric phenomena.

Since returning to England, Mr. Blanford has been a not infrequent contributor to *Nature*; and among his articles, we find two of especial value on Hann's discussion of the Sonnblick observations and their bearing on the convectional origin of cyclones.

It was my good fortune to meet Mr. Blanford on the steamer between Madras and Calcutta, in 1878, and to see him afterwards at his office in Calcutta. Since then, he has at various times responded in the kindest way to my inquiries. My last letter from him mentioned his disability, from which he did not

recover, and on account of which he had to postpone a contribution that I had asked him to make to our METEOROLOGICAL JOURNAL.

A brief account of his life is given in *Nature*, Feb. 2, 1893.

OSCILLATIONS OF LAKES (SEICHES).

THE nature of oscillations of lakes or seiches was explained by Mr. E. B. Perkins, who referred briefly to the studies of Prof. Forel, of Switzerland, and mentioned some of the few results of observations on seiches in this country. He illustrated the manner of uninodal oscillations in lakes by experiments with water in a tank; varying the depth and length in a way to show a systematic variation of the period of oscillation. He stated that an essay on this subject was in preparation for publication.

Prof. Davis mentioned the strong waves noted at several points on Lake Michigan early in the morning of April 7, 1893. He reported having sent out letters of inquiry to observers at several points on the lake shore, from whom a number of interesting statements were received, which will be given in full in the essay by Mr. Perkins on the occurrence of seiches in this country. The wave of April 7 was manifestly produced in connection with a strong and sudden rise of pressure that accompanied a violent wind storm, a local disturbance within an extended cyclone. The sudden increase of atmospheric pressure, as recorded on barographs at Chicago, Milwaukee, and elsewhere, did not exceed two tenths of an inch of mecury, or about three inches of water pressure; it is plain that the waves in Lake Michigan, which were reported to have a height of four or five feet, could not be a direct result of the increased pressure. As the waves were associated with alternating currents, of a period measuring about twenty minutes, in several harbors along the lake shore, they cannot be explained by the direct action of the wind, which had no such periodic variation in velocity or direction. Hence the waves and the associated currents must be referred to exaggerations along the shallowing waters of the lake shore, of smaller oscillations resulting from varying atmospheric pressure on the body of the lake; they may in this way

be compared with the bore or "mascaret" of the lunar tides in the estuaries along the shores of the ocean.

From the correspondence he had received, Prof. Davis felt confident that a large amount of interesting information might be gathered by interrogating the fishermen and pilots of our Great Lakes; and still more by examining the automatic records of tide gauges established at various lake ports by the army engineers on duty there in connection with public works.

METEOROLOGY AS THE PHYSICS OF THE ATMOSPHERE.

PROF. WILHELM VON BEZOLD.

[*Translated by* Prof. Cleveland Abbe *from* Himmel und Erde, *Oct.*, 1892, *Vol. V., pp.* 1–19, *and published by permission of the Author.*]

Continued from page 10 of the May number of this JOURNAL.

THE temperature indicated by a thermometer exposed to the air does not depend upon the temperature of the surrounding air alone, but also upon the extent to which the thermometer is influenced by the heat radiated to it and from it. It has long been recognized that thermometers in close proximity to each other may show entirely different readings according to their own nature and their immediate surroundings, and that the nature of the walls in their vicinity and numberless other accessory circumstances, may exert a substantial influence upon them. Therefore from the earliest times these instruments have always been hung up in the shade of a house or under special protecting contrivances known as thermometer-shelters.

But even when a thermometer has been hung on the north side of a house, and when this house is so favorably situated that it is shielded from the morning and evening sun, even in midsummer, by neighboring, but not too near buildings, even then the effect of radiation is not wholly removed.

Just as during day time the thermometer is, by the radiation of the sun, warmed above the temperature of the surrounding air, in the same way will it be cooled below this temperature, on clear nights, by its own radiation towards space.

In order to diminish these disturbing influences all manner of sheltering arrangements have been devised, tin screens,

jalousie, houses of open slat-work of wood or metal, special shelters, etc., so that nearly every system of stations has its own particular arrangement about whose adaptability opinions differ widely.

This much has, however, long been known, namely, that the resulting temperatures vary according to the style of exposure and shelter, and so much the more as the air is quieter; but which of these results are those that approach nearest to the truth was until recently quite undecided as there was no normal exposure by means of which it could be shown that the influence of radiation is really overcome.

The differences which variously-exposed thermometers show among themselves are confined within comparatively narrow limits so that, at least, the average values generally differ only by the fraction of a Centigrade degree, whereas the individual readings may differ much more from each other, as occurs especially during a calm.

Now in a balloon, so long as it does not come into the immediate neighborhood of the clouds, particularly of thunderstorm clouds, there is always perfect calm since it moves with the wind. Therefore here the influence of radiation shows itself most distinctly and it is, therefore, not improbable that in older records of temperatures observed during balloon voyages, the errors have often amounted to as much as six degrees Centigrade or even more.

These disturbing influences have within the past few years been entirely avoided by the aspiration-psychrometer invented by von Assmann; called a psychrometer because by the side of the dry thermometer used to determine the temperature of the air, it contains also a wet-bulb thermometer, in order to be able to compute the atmospheric moisture from the differences between the readings of these two thermometers.

The elimination of disturbing radiation has been attained by enclosing the bulbs of the thermometers in highly polished double-walled nickel-plated tubes which are open at the bottom and through which, by means of an aspirator placed above the instrument and driven by clock-work, a strong current of air is drawn up.

In this way the thermometer is constantly in a current of air that has not come into contact with any body having a different

temperature, since the thin-walled tubes very quickly take the temperature of the current of air whilst the high polish almost entirely excludes radiation.

That this result is really attained follows from the fact that in powerful sunshine, such as prevails on clear, summer days in the high Alps, it is quite indifferent whether the instrument is exposed to the full sunshine or whether it is shielded therefrom.

In fact, the possibility of obtaining correct temperature readings in the so-called "Urania Columns" that have been established in Berlin within a few months, rests upon the application of the same principle whereas nearly all the older "weather columns" seem to be intended rather to awaken false meteorological ideas in the public mind than to offer real instruction.*

Indeed, by means of the "Urania Columns" a problem has been solved which every scientist would, even a few years ago, have pronounced to be simply impossible of solution.

Since, however, by the ingenuity and perseverance of the inventor, we have been put in possession of the aspiration instrument, and since he has shown how even the best results obtained by former balloon voyages are infected with important uncertainties, it is of the highest importance to again take up the work that the Englishmen, Welsh and Glaisher, carried out a few decades ago with so much boldness as well as discretion, and which, being continued later by French aeronauts, has contributed so greatly to enrich science.

Especially should we, in Germany, be interested in this work since we have only recently begun, first in Berlin and then in Munich, to enter into competition with other nations in this domain of science, and since it is precisely a German who has succeeded in overcoming the great difficulties which formerly stood in the way of obtaining correct results in balloon voyages.

It may here be permitted to emphasize some points the elucidation of which we can only expect to attain in this way.

The most prominent question whose precise answer interests us is that of the temperature and moisture at various elevations and under various conditions of weather, that is to say, under

[* Evidently the "Urania Columns" are pillars set up in public thoroughfares by the "Urania Gesellschaft" as an advertisement of the Society, and also, for the dissemination of meteorological information. C. A.]

the influence of cyclones or anti-cyclones, in winter or in summer, by day or by night, since thus only is it possible to decide how far the hitherto universally-accepted convection theory is tenable and how far it must be modified.

Furthermore it is of particular importance to ascertain the changes that the law of decrease of temperature with increase of elevation experiences when we pass from clear air, whether it be dry or interspersed only with raindrops, into the clouds themselves.

It may be accepted as proven that the most essential cause of cloud and rain formations is to be sought for in the cooling that the air undergoes in rising. This cooling may be calculated, if we assume that heat is neither conducted to nor drawn away from the rising air, and, further, that on one hand no other air is mingled with it than that which has simultaneously risen with it from below.

These two assumptions are, however, only exceptionally admissible in the free atmosphere, although they are to a certain degree fulfilled in the mechanism of the "Foehn" which has served as the point of departure for all these investigations.

On the other hand the observations of the clouds, particularly of those that are in process of disintegration at the rear of the cyclone (*i. e.*, when rainy weather ceases and clearing weather begins) teach that the rising current of the cyclone is at various heights mixed with air from the neighboring anti cyclone, which air, however, had not as yet descended to the earth's surface.

How great this proportion of this intermixed air is, or how important is the warming or cooling which the air undergoes in these processes, are questions that must be explained by the above-suggested observations and determinations of temperature, both below and within the clouds.

All of these investigations become far more interesting when the balloon reaches the upper limits of the clouds and penetrates them.

In a certain sense these cloud surfaces play the same role as that which, with an unclouded sky, devolves upon the surface of the earth although in a peculiar, highly complex manner.

In the first place there occurs at this upper surface a powerful reflection of the sun's rays which, until now, has not been

sufficiently appreciated, although from this, the most remarkable consequences must follow.

We need only, for example, to be reminded that an increase in the intensity of the solar radiation, such as probably takes place at certain periods, although it has not yet been proved, might even bring about a decrease of temperature at those parts of the earth's surface that particularly favor the formation of clouds, since the thickened and broadened cloud-covering must diminish the communication of heat to the earth's surface.

It would not be inconceivable if, in these conditions, we should find the explanation of that remarkable periodicity in the temperature of whole zones, demonstrated by Koeppen in the year 1873, and which, without doubt, indicates a close connection with the processes on the surface of the sun, although the irregularities in the times of occurrence of the maximum and minimum temperatures, amounting to years of delay in certain zones, seems, at first sight, to prove that there is no such connection.

But simultaneously with this reflection at the upper surfaces of the clouds there goes on a powerful evaporation that gives rise to characteristic phenomena that had already been theoretically predicted, and now, indeed, are proved to be correct, by balloon voyages.

Not less important than the questions above indicated are the conclusions to be expected from these voyages as to the altitudes to which the atmospheric whirls prevail, and up to which movements in the same direction take place.

The determination of the heights at which the flow into a depression becomes an outflow and which, in particular cases, appears to be not very considerable, is a matter of the very greatest importance.

The peculiar conditions that occur in this respect are shown by experiences in reference to the almost perfectly horizontal strata of clouds, often of only very moderate thickness, which the aeronauts often pass through at very moderate heights above the earth's surface and which, as the boundary layers between two currents of air, must for the most part be produced by mixture.

Such broadly extended, perfectly horizontal cloud-layers appear to occur very often, especially in winter, but their

presence cannot be recognized except from the balloon, since at those times the sky is entirely covered with gray haze without its being possible, at least in the lowlands, to measure the elevation of this layer above the ground or to judge of its thickness.

It is scarcely necessary to point out how intensely interesting it is to also obtain light upon the nature of the clouds and, as an illustration of this, it may be recalled that in balloon voyages clouds have often been encountered within which the temperature was far below the freezing-point and which, notwithstanding this, contained no particles of ice but only globules of fluid water, a fact from which very important conclusions may be drawn.

These few facts are sufficient to give an idea of the great importance that attaches to scientific balloon voyages. May we succeed in arousing such an interest in them that the "Societies for balloon navigation" may be entrusted with the considerable sums of money that are necessary in order to carry out these undertakings.

The consideration and enumeration of the problems to be solved by aeronauts has finally led to investigations into the nature of the clouds and thence to a field of investigation which in connection with the observations in balloons promises the most important conclusions as to the processes going on in the free atmosphere and the cultivation of which must claim our attention in an eminent degree.

In point of fact the observations of the form and motion of the clouds have within the last few years come more and more into prominence.

But just here it is of the greatest importance to always keep clearly in mind the direction in which the development of science is tending, for the danger of false conclusions and overhaste is unusually prominent in meteorology.

There are two points that are being principally considered at this time; first, the observations on direction and velocity of motions of the clouds, especially of the high, delicate cirrus clouds, as an aid to the determination of the movement of the air at their level, and secondly, the classification of the clouds according to their external appearance.

On the other hand, it seems to the writer of these lines that the formation and dissipation of the clouds do not receive as

much attention as the importance of these processes deserves, and it is therefore to be feared that in the treatment of both the other questions also, errors will creep in that ought to be avoided.

Care must be taken not to regard a cloud as a formation that, to a certain extent, floats in the air and whose movement must therefore be the same as that of the air.

The temptation to admit such a conception is very great since one too easily inclines to the idea that in clouds of smoke he has a complete analogy to clouds of water or ice, such as float in the atmosphere.

There is, however, a very great difference between such clouds; smoke is a foreign substance which simply floats in the atmosphere and then slowly and gradually sinks down as soon as the gases issuing from the chimney have lost their ascensive power, through mixture with the cooler air.

On the other hand, the vapor of which the clouds are composed, exists in greater or smaller quantities everywhere in the air, although it is only visible where condensation takes place; the cloud is therefore only an image of a process and it is not at all admissible to conclude anything as to the movement of the air from the observed movement of the cloud. Even though such a conclusion might be proper in many cases, still many other cases are known in which it would be entirely erroneous.

Thus experience in mountainous regions has shown that clouds may hang apparently motionless over the mountains while in reality these latter are being swept by violent storms. Such clouds form and disappear continually at the same place and thus offer a picture of apparent calm just as a waterfall, or better still a flowing river, seems to be stationary, seen from a distance, although the water of which it is composed is constantly being renewed.

Clouds may even seem to sink downwards although they are produced by a rising current of air, which, on account of increasing moisture or decreasing temperature, attains its point of condensation at altitudes that are steadily diminishing.

Similarly the experience of aeronauts teaches that clouds are not infrequently traversed, in a horizontal direction, by the balloon, whereas this latter, by virtue of its internal buoyancy and its inertiae, is only subject to forces that act vertically.

The most remarkable example, however, of the great difference that exists between the real motion of the air and the apparent movement of the clouds is offered by clouds that occur in rows (rank and file) which are met with in the most various strata of the atmosphere, and which, when at their greatest heights, give rise to the so-called fleecy clouds ("Schäfchen-Wolken" or like flocks of sheep).

If the formation of such clouds be examined more closely, it will be observed that often a part of the heavens is suddenly covered with clouds that are arranged in parallel rows, and give an impression of the greatest regularity; and that, soon afterwards, this system is traversed by a system of other parallel lines, so that the clouds, as a whole, separate into little squares and then pass into the known form of the mackerel sky.

These serial clouds always originate, as Helmholtz, only a few years ago, proved theoretically, whenever two strata of air of different temperatures glide over each other with unequal velocities. In such a case waves must form and the series of clouds that then arise is the perfect counterpart of the ocean waves with their foaming crests.

We here see before us aerial breakers, and it is the mass of material from the lower layers that is hurled up into the upper strata of air, that, partly by mixture and partly in consequence of their cooling by expansion, give rise to the formation of the clouds in regularly arranged stripes. Here, therefore, we have again a case in which the apparent progressive motion of the clouds does not in the least permit of any conclusion as to the velocity of the motion of the air, any more than the apparent progress of waves of water permits a conclusion as to the velocity of the wind or the movement of the particles of water.

On the other hand very important conclusions may be drawn from the breadth of these stripes which matter, however, cannot be further entered into here.

Again, the velocity with which the formation of these billow-clouds or cloud-billows, as they are called by v. Helmholtz, in a peculiarly appropriate manner, propagates itself, is not a measure of the velocity of the wind, but only of the rate of progression of atmospheric waves.

These billow-clouds have their longest dimensions perpendicularly to the direction that we obtain when we imagine the

more slowly flowing stratum of the two to be at rest, that is to say, perpendicular to the relative motions, or the resultant of the movements of the two strata.

Were one of these layers of air, for instance the lower one, really at rest the cloud waves would simply be perpendicular to the direction of the wind above it.

On the other hand, there are also stripe-clouds, the so-called stripe-cirrus or polar bands, whose longitudinal direction probably coincides with that of the wind.

This example is very instructive because it shows how dangerous it is, in studying these observations, for us to consider only the external appearances without thoroughly investigating the matter. Only a short time ago there appeared a memoir on the so-called radiating point or vanishing point of the clouds, (that is to say, that point towards which parallel cloud stripes converge perspectively) that announced a very astonishing result.

It is probable that this result was attained only because the stripe clouds, that are perpendicular to the direction of the wind, and those others that coincide with that direction were united indiscriminately in a common average.

The theory of the atmospheric billows, by means of which a phenomenon that has been long known but never rightly construed immediately found its simple and natural explanation, is one of the greatest acquisitions to our knowledge of the subject under consideration.

It is a remarkable fact that in the new atlas for the classification of the clouds no attention has been given to this theory; and, in that system, we seek in vain for an appropriate title for the billow clouds which occur, with numerous modifications, in the most diverse strata of the atmosphere.

Precisely for this reason a word of caution is proper, *i. e.*, that we do not proceed too rashly to invent, for the classification of the clouds, an artificial system based on methods or descriptions of the outward appearances similar, for instance, to that of Linnaeus for plants, which pays no attention to the formation and dissolution of the clouds and, therefore, is not adapted to further our understanding of these phenomena.

For the same reasons it is worth while to urge that only such persons as are thoroughly schooled and are furnished with the

best apparatus and methods should be set to work on these most important but most difficult observations, since here, if anywhere, is the motto applicable, "Multum sed non multa."

Fortunately at the present day these investigations, at selected stations, may be undertaken with so much the greater hope of success since the methods and apparatus have, within the past few years, been carried to an unlooked-for perfection.

Photography has recently succeeded in re-producing even those delicate images that mocked the power of the ordinary photographic methods and especially has Dr. Neuhauss, M. D. of Berlin, obtained most astonishing results.

In the same way, the highly-perfected methods of photogrametry, or the measurement of photographic pictures, has in very recent years enabled us to determine with the greatest accuracy, the height, form and movement of the clouds, as is shown by the fine results obtained by Jesse, by the application of this process to the self-luminous nocturnal clouds.*

When the measurements of the clouds have been thus carried out and their changes accurately followed up, and when the results, so obtained, are united with the observations made on the surface of the earth, and with the records obtained in balloons, then we will also succeed in learning how, from the forms of the clouds, to read the history of their appearance and of disappearance.

Then also will it be possible to establish the classification and nomenclature of the clouds upon a natural basis and, as G. Hellmann expresses it, "to raise the study of the forms of the clouds from a pure system of external appearance to one of the physiology of these forms"

I have attempted in the foregoing paragraphs to emphasize some of the most important questions that the present state of scientific research suggests for investigation, and especially have those been considered whose solution would be of great advantage to the whole domain of meteorology.

It is not necessary to insist upon the fact that, along with these may be enumerated whole series of other problems not inferior to them in interest. Thus incidentally consider what a

[* This is a special class of delicate clouds seen at midnight in June in Germany and, apparently, shining by the reflection of distant northern twilights. C. A.]

vast field of work is offered to investigation by the insolation of our planet, as well as by radiation from the earth, or, recall the investigations of electrical phenomena which, in the past few years, have been so greatly advanced by Exner in Vienna as well as by Elster and Geitel in Wolfenbuettel, to say nothing of the development and completion of all the fields of investigation formerly occupied and which should not be forgotten.

When, however, we consider those questions that belong so peculiarly to the present time we find that in spite of variations in detail still there is clearly a certain common resemblance; be it the motions of the atmosphere or the thermal economy of the earth; be it questions of the greatest generality that man can make the subject of his investigations, or be it definite special limited cases; whether we follow the ever-changing play of the clouds or the mysterious displays of atmospheric electricity; our endeavors should always culminate, not alone in framing empirical rules, but in penetrating into the nature of the phenomena; thus gradually placing meteorology upon a firm basis and transforming it into the "Physics of the Atmosphere."

THE SLING PSYCHROMETER IN A BALLOON.

PROF. H. A. HAZEN.

IN the February number there was given, at page 453, a comparison between the sling and aspiration psychrometers showing that there was no difference between the two. Exceptions were also taken to the views expressed by Mr. Rotch in an earlier number, namely, that in the strongest sunshine a sling thermometer would sometimes indicate a temperature 5.4° F. higher than in the shade, and that the relative humidity given by the sling psychrometer was lower in bright sunshine than in shade. Mr. Rotch has attempted to answer my objections at page 456, and I desire to note one or two points farther.

As I understand it, Mr. Rotch now agrees with me that the sling in the sun does not give more than 0.5° F. higher than in the shade. As to comparative readings on high glaciers and snow fields we have nothing to do with them, for there are none such where the balloon is. Though relinquishing this ground,

Mr. Rotch still insists strongly that the sling cannot be used far enough outside the basket to be removed from the heat radiated by the balloon and the envelope of air which passes over it. As to the heat radiated by the balloon, I think nearly every one will admit it must have only an infinitesimal effect upon the temperature of a sling. If the temperature of the bulb in the direct rays of the sun is only 0.5° F. above that in the shade, then surely the direct radiation effect of a balloon heated three or four degrees above the air must be exceedingly slight. The effect of heat from the envelope of air is a slightly different question and can be settled only by actual observations. I think those given by Mr. Rotch will settle the question at once, for they show that when the balloon was rising most rapidly, some of the time 66 m. per minute, and at which time the effect of the heat from the envelope of air about the balloon would have been greatest, the actual difference between the sling and aspiration was only 0.6° C. On the other hand, when the balloon was moving horizontally, or at a time when we would expect the least difference, in fact, none from this cause, the observed difference was nearly 2.0° C., and in one case 3 0° C., or five times as great as in the rapidly rising balloon ; I am sure no clearer proof of the non-effect of heat from the air about the balloon in a rapid ascent could be desired.

Mr. Rotch states that five miles per hour is rapid enough for the current in the aspiration psychrometer. I will yield for the moment that such a current may be satisfactory with a stationary psychrometer, but it is far otherwise with a psychrometer rapidly moving into conditions of temperature and humidity which differ widely from those just previous. Under such circumstances a current of fifteen miles per hour would be all too sluggish.

As regards the statement that Jelinek's tables must be used with the sling psychrometer and Sprung's with the aspiration, there must be a most serious error. Jelinek's tables are for an unventilated psychrometer and cannot apply in any manner whatsoever to the sling psychrometer. Moreover, the very object of my paper was to show that the Sprung formula for the aspiration psychrometer was identical with that for the sling as found by two independent observers in this country. In the table on page 458 there seem to be several slips in the reduc-

tions which are not easy to explain and which necessarily change any deductions made.

RELATIVE HUMIDITY.

No. of observation,		4	5	18	19	20
Rotch	Aspiration,	83	82	67	73	69
	Sling,	85	81	76	70	64
Should be	Aspiration,	79	82	66	72	68
	Sling,	84	91	64	72	66

These are the only ones I have examined. In the fifteenth observation there is a typographical error of 19 for 9.

APRIL 3, 1893.

RULES FOR WEATHER FORECASTING.*

WILLIS L. MOORE.

IT would be impossible to lay down a set of rules for the making of forecasts which would fit the details of all cases, or in fact any considerable number of cases. To be sure, there are a few general principles which govern all of this work, and some which apply only to particular localities. The barometer change chart, showing twelve and twenty-four hour changes, should be the constant study of the forecaster. It will generally show whether the storm is increasing or decreasing in energy, and often will point out to the intelligent student of the subject the future track of the storm centre. In the ordering of wind signals this chart is invaluable.

GENERAL RULES.

1. Any considerable rise in barometer during the past twelve hours, shown on the morning chart, over a region five to eight hundred miles to the southwest, is the most reliable indication known of fair weather on the morrow; or, if a marked fall be shown, foul weather may with equal certainty be predicted.

2. Low pressure areas which approach from the southwest are reasonably sure to cause precipitation, while many from the northwest will pass with little or no rainfall.

3. A twelve-hour barometer fall at the storm centre, less than one half the twenty-four hour fall, indicates that the low is filling and losing its energy as a storm condition. The centre of the

* Reprinted from the *Wisconsin Weather and Crop Journal*, for March, 1893.

greatest twelve hour fall, as charted by the blue lines, when much in advance of the twenty-four hour fall, strongly indicates the future direction of the storm. The region of greatest heat and heaviest rainfall also indicates the future storm track, but the twelve-hour decrease in pressure as compared with location of the twenty-four hour change, will often be found of great service when temperature and rainfall furnish no guide whatever. Unfortunately, many cases arise when none of the indicators can be strongly relied upon to give the desired information as to the future course of the storm.

4. Approach of the storm centre from the west is attended by warmer, easterly winds, and usually precipitation; its passage is followed by colder, westerly winds and fair weather.

5. The idea long entertained that a low pressure or storm area is compressed by its progressive movement on the side towards the direction in which it is moving, *i. e.*, elongated north and south if the storm movement be east, and that the amount of compression will be in proportion to the velocity, is entirely erroneous. The storm does not move in the direction thus indicated. That a low pressure area is compressed into an oval or elliptical form, with the elongation in the direction of the poles, clearly indicates that a formidable obstruction in the shape of a large body of heavy air, lies directly east of the storm centre, and that, instead of the storm moving rapidly in that direction, its movement of translation already has been checked, and it will be deflected to the northeast or southeast. In fact, some of the most rapidly moving storms are nearly or quite circular in form, and move swiftly across the country without encountering any highs sufficiently heavy to change their shape or impede their progress.

6. Trough like or V-shaped lows are quite sure of precipitation, and if the barometer be five to seven tenths below the outer limits of the depression, heavy precipitation and destructive local storms may be expected.

LOCAL RULES.

1. The maximum heat in summer in Wisconsin occurs after the centre of low pressure has passed a little to the east, and southwest winds are blowing. The easterly winds from the lake are, of course, cooler than southwest land breezes.

2. A low from the northwest which reaches Western Minnesota and Western Iowa without rain or clouds, will pass over Wisconsin as a dry low, unless the isobars run closer than five-eighths of an inch.

3. Light frosts will occur on clear quiet nights in cranberry marshes when minimum temperatures at Duluth and La Crosse fall to 40 and 45 degrees respectively. When these stations record 5° lower the frost will be killing in the cranberry marshes, and in the tobacco fields, to the south, light. No frost will occur in the counties bordering on Lake Michigan unless the temperature at the Weather Bureau stations falls very close to the freezing point, such is the influence of the water in slowly radiating heat and keeping up the night temperature.

4. During July and August, or at any time when the maximum temperature of the day equals 80°, it will not do to predict warmer weather in the eastern half of Wisconsin, when a low is approaching from the west and easterly winds are expected, the same as would be done for regions remote from the lake ; cooler must be predicted. At other times the usual temperature forecast may be made for the approach and passage of a low, and it will hold good for all parts of the State, except that it should always be borne in mind that the influence of the lake is to modify radical temperature changes.

CURRENT NOTES.

Preliminary Address of the Committee of Arrangements of the World's Congress Auxiliary for a Congress on Meteorology, Climatology, and Terrestrial Magnetism. — It has long been recognized as redounding to the credit of America that the first International Meteorological Congress officially recognized by the governments of the world was that which was called together in 1853, at Brussels, at the request of the Government of the United States.

Since that event many important international conferences have been held, but it is considered that there is still need of further unification in meteorological methods and objects, and that progress in the future will be greatly facilitated by a comprehensive discussion of the present status of this branch of applied science. To this end, the World's Congress Auxiliary has arranged for a series of meetings in which meteorologists and climatologists of all countries may gather together for the interchange of views and the discussion of the living questions of to-day in this field of science.

The World's Congress Auxiliary is a separate organization, working in entire harmony with the World's Columbian Exposition; it is recognized by the United States Government, and is to a certain extent supported by the funds appropriated by it. The Directory of the Exposition has undertaken to provide the audience rooms for the meetings of the Congress, and to defray the expenses incidental to the meetings. Arrangements will be made for the publication and distribution of the proceedings of the various congresses to be held.

Such a Congress as this has a private and personal aspect in that all attendance on it is entirely voluntary. On the other hand, it has an international and official importance in that matters of general and international importance will be discussed by men of world-wide reputation, who will hereafter have a powerful influence in shaping the course of future legislation by the respective nations.

The General Committee on Meteorological Congresses, to which has been intrusted the arrangements of such details as may contribute to the success of the meeting, is deeply impressed with the importance of the subject that is to be considered. The rapid progress of all the sciences during the past fifty years gives us good reason to anticipate a still more rapid progress in the future. It will be the object of the Congress to briefly review the progress that has been made up to the present time, in every branch of meteorology and its applications to agriculture, navigation, engineering, hydraulics, wind-mills, etc., and its bearings on questions of geology, and the acclimatization and distribution of plants and animals. Even the connection between meteorology and the magnetism of the earth, the earth-

quakes, the volcanoes of the earth, the meteoric shooting stars, the aurora, and the varying condition of the sun, all have their place in such a discussion.

The subject of Economic Meteorology will also receive due consideration. From the standpoint of the people at large, the measures of success are dollars and cents. Upon the people depend the means of future improvement, and in no way can their interest be more easily enlisted than through the medium of the practical affairs of business.

Some time will also be devoted to the topic of Meteorology in the schools. As the importance of a knowledge of Meteorology impresses itself upon the public mind, the day will come when a common-school education will be considered deficient unless at least rudimentary instruction has been given in the principles of this important subject.

The following classification of topics is suggested as showing the appropriate range of subjects, including many that should be referred to special or subcommittees, and be discussed in special meetings of the Congress : —

a. Instruments and Methods of Observation. In this section should be discussed all questions relating to meteorologic instruments, observations, reductions, corrections, and analysis.

b. Meteorologic Science, to include topics in theoretical meteorology, cyclones, secondary storms, etc.

c. Climatology.

d. Agricultural and Hygienic Meteorology.

e. Marine Meteorology.

f. Government Weather Service, to include topics of weather telegraphy, predictions, verifications, special thunderstorm, and other service.

g. Terrestrial Magnetism and Atmospheric Electricity, including magnetic storms, cosmic magnetic fields, magnetic and electric instruments, lightning, auroras, etc.

h. Geologic Climate, including such topics as the glacial age, quarternary changes in climate, climate as shown by fossil fauna and flora.

i. Meteorologic Literature, Bibliography and Biography.

The committee anticipate that the official public gatherings will be largely supplemented by private, personal conferences, and that the acquaintances thus made will greatly facilitate harmonious action among meteorologists for many years to come.

The Exposition will be open from May to October, 1893 ; it is proposed to hold the Meteorological Congress during the week commencing on Monday, Aug. 21, 1893, which has been assigned to the scientific congresses generally, in order that those who desire to attend other scientific congresses can conveniently do so.

The special sections into which the Meteorological Congress is subdivided, for convenience and expedition, and the gentlemen appointed to prepare for the work of these sections, will be announced at an early date.

The object of this preliminary address is to acquaint those interested

with the general steps that have already been taken toward the organization of a Meteorological Congress and to cordially invite the active co-operation of all Government Weather Bureaus and all individuals and societies interested in this branch of applied science. We invite correspondence and suggestions from any one who may read this address in relation to subjects to be discussed; persons to prepare papers, and modes of proceeding in the work of the Congress. Efforts have been made to secure special reports on the present state of our knowledge from a few who are specially familiar with individual topics, but as it may easily happen that the committee has overlooked others of equal importance, the Chairman will esteem it a favor if any one who has devoted himself to any given branch of meteorology will put himself in communication with the committee. Inquiries may be addressed to the headquarters named below. Documents explaining the plans of the Auxiliary will be furnished on request.

MARK W. HARRINGTON, *Chairman.*
H. C. FRANKENFIELD, M. D., *Vice-Chairman.*

ELIAS COLBERT,	W. S. JACKMAN,
CHARLES B. THWING,	OSSIAN GUTHRIE,
WILLIAM S. SEAVERNS,	R. GRIGSBY CHANDLER,
RICHARDSON CLOVER,	FRANK H. BIGELOW,
F. E. NIPHER,	G. K. GILBERT,

Committee of the World's Congress Auxiliary on a Meteorological Congress.

WORLD'S CONGRESS HEADQUARTERS, CHICAGO, ILL.,
December, 1892.

Dew and Frost. — The latest contribution to the subject of dew is a pamphlet recently published by Stanford, of London, entitled "Observations on Dew and Frost," by Hon. R. Russell, F. R. Met. Soc. The following extracts are from the author's "Summary of Results," which was printed in full in "Nature" for Dec. 29, 1892.

In nearly all the conclusions of Wells, as stated in his admirable "Essay on Dew," my observations lead me to concur. He found that calm is favorable to the precipitation of dew; that if, in the course of the night, the weather, from being calm and serene, became windy and cloudy, not only did dew cease to form, but that which had formed either disappeared or diminished considerably; that if the clouds were high and the weather calm, dew sometimes formed to no very inconsiderable extent; that dew often forms on shaded grass even several hours before sunset, and continues to form after sunrise; that, if the weather be favorable, more dew forms a little before, and, in shaded places, a little after sunrise, than at any other time; that on substances elevated a few feet above the ground it forms much later in the evening, but continues to form as long after the rising of the sun as upon the ground; that dew is more abundant shortly after rain than during a long tract of dry weather; that dew is always very copious on those clear and calm nights which are followed by misty or foggy mornings, and also on clear mornings after cloudy nights, and generally after hot days; that more dew was formed between midnight and sunrise than between sun-

set and midnight, owing doubtless "to the cold of the atmosphere being greater in the latter than in the prior part of the night"; that whatever diminishes the view of the sky diminishes the quantity of dew; that a substance placed on a raised board of some extent acquired more dew on a very still night than a similar substance lying on grass; that bright metals attract dew much less powerfully than other bodies; that a metal which has been purposely moistened will often become dry though similarly exposed with bodies which are attracting dew, and that wool laid upon a metal acquires much less dew than an equal quantity laid upon grass in the immediate vicinity; that a metal plate on grass always became moist on the lower side during the night, though the upper side was often very dry, but that if the plate was elevated several feet in the air, the condition of both sides was always the same, whether dry or moist; that wool on a raised board was commonly colder than on the grass on very still nights, and that the leeward side of the board was colder than the windward; that bare gravel and garden mould were very much warmer after sunset than neighboring grass; that on dewy nights the temperature of the earth half an inch or an inch beneath its surface was much warmer than the grass upon it, and than the air; that metal covering grass was only slightly colder than the grass covered, and this again colder than the earth; that metal thus exposed was warmer than air four feet above it, and much warmer than neighboring grass; that the variety in the quantities of dew formed upon bodies of the same kind in different situations, was occasioned by the diversity of temperature existing among them; and that on nights favorable to the production of dew, only a very small part of what occurs is owing to vapor rising from the earth.

The last of these conclusions Wells supported by the observation that the dew on the grass increased considerably about sunset, the same time at which dew began to show itself on the raised board, and by the reflection that, "though bodies situated on the ground after they have been made sufficiently cold by radiation to condense the vapor of the atmosphere will be able to retain the moisture which they acquire by condensing the vapor of the earth; yet, before this happens, the rising vapor must have been greatly diminished by the surface of the ground having become much colder." He adduced the fact that substances on the raised board attracted rather more dew throughout the night than substances lying on the grass. He admitted that all the dew on calm, cloudy nights might be attributed to condensation of the earth's vapor, since on such nights the raised board was dry.

But if the grass was moist on these calm, cloudy nights, and the moisture were owing to earth vapor, it is only reasonable to infer that a very much larger quantity was owing to earth vapor on clear nights when radiation was comparatively free. Moreover, the fact that substances on the raised board became wetter than substances on the grass may be attributed to the non-conducting wood intercepting the warmth radiated from the ground, and thus allowing a substance on the upper surface of the board to become colder than a substance on the grass. And with regard to the "rising

vapor" being greatly diminished by the surface of the ground having become colder, it does not appear that such diminution actually occurs, owing possibly to the influence of the high temperature of the preceding day reaching the moist earth at a little depth below the surface about the same time. I have found the deposition of earth vapor to proceed at a rapid rate after sunrise over grass.

Wells explains with much ingenuity the reason why leaves of trees often remain dry throughout the night, while those of grass are covered with dew. But he does not, I think, attach sufficient weight to the fact which he mentions among others, that the air near the ground is near one of its sources of moisture, while the tops of trees are removed from that source. The air is both damper and colder near the ground; a stratum of cooled air rests upon warm earth emitting vapor. The tops of trees are prevaded by air which is drier and warmer, and the leaves do not allow air to rest long enough on their cooled surfaces to part with sufficient heat in order that condensation may ensue.

I have found that when the air is clear and not humid, radiation into space is often not sufficient to cause visible dew or frost except in sheltered, calm places, and in the same condition of air deposition takes place more on broad surfaces than on thin shoots, threads, and points, and more on the faces than on the edges of leaves. It appears necessary that a certain stability of temperature below that of the air, and a certain protection from re-absorption by the drier portions of air which pass over, should be attained in order that dew and frost may accumulate. When, on the other hand, the air is very moist, with a tendency to mist or fog, a very large condensation takes place on exposed objects, and especially on those which are at some height above the ground, such as the branches and twigs of trees. Points, thorns, spiders' webs, and other thin filaments are then heavily bedewed. Mist or fog often follows.

When some mist has formed on such a night, there is a heavy precipitation on trees, etc., which is increased by wind, and large drops of rain on to the ground beneath them. This condition seems best explained by Aitken's discoveries showing the possibility of a super-saturation of air when the number of dust-particles is unusually small in a mass of air which is humid and cooled to saturation. The dust-particles from their minuteness, and from their inability to fall below the temperature of the air owing to the cloud canopy above, do not condense much of the vapor, and consequently any solid object of the same or slightly lower temperature brings about precipitation from the passing air, which may possibly be super-saturated. A slight fall of temperature in the air, or sometimes an increase of dust-particles, then produces fog. A dry fog may thus result from cold causing condensation on a very large number of dust-particles which are radiating heat rather freely, and a damp mist from partial condensation from super-saturated air on a comparatively small number of dust-particles not radiating freely owing to a clouded sky.

These considerations explain why a dry fog is densest in London and a wet mist densest in the country. A dry fog is the work of cold radiating

particles, a wet mist is the work of cold air mixing with warm. "In a fog," says Angus Rankin,* "the watery vapor in condensing has more particles to condense on, and consequently the particles of fog are smaller, and on meeting with an object with a higher temperature, instead of wetting it, the object dries them up by parting with some of its heat. On the other hand, in a mist, the particles of dust, being few, have more water condensed on each, and so are larger and do not readily evaporate with small increments of heat." Yet in a damp mist the addition of a large number of dust-particles, as in a town by day, scarcely increases the density of the mist. In fact, the wet mist is less dense in London than in the country, owing to the higher temperature and lower humidity of the air. Dry or radiation fogs, which cling to the ground, are the most dense in smoky places.

In fogs with frost in winter, such as have occurred several times in the last few years, I have always found the windward side of objects to be much more heavily frosted than the leeward, and the rime to attach itself most to points and edges. Trees have thus become laden with rime, even so as to break down branches; iron points of railings, splinters of wood, wires, and blades of grass have borne spikes and fern-like growths an inch or more long, and heather and ferns in hollows have been whitened as if with a fall of snow. In weather of this kind it is difficult to say what is dew or frost proper, and what is deposited moisture from super-saturated air and from fog. On the same night a white frost may present the characteristics of fog-deposition in a valley and of clear condensation on a neighboring hill.

Dew and frost are in fine the result of many causes which inter-operate in a complex manner. The importance of the laws of gases of the multitude of fine adaptations in the relations of vapor, air, water, earth, and plants; the importance, too, of the thermal receptivity of boundless space, gives an interest to this branch of meteorology which is second only to its beauty.

Oregon Weather Bureau. — The Second Biennial Report of the Oregon Weather Bureau, recently issued, contains much valuable information concerning the climate of that State, as well as notes on its production and its soil. The Oregon State Weather Bureau was created by an act of the State Legislature, approved Feb. 25, 1889, and is doing most creditable work under the direction of Mr. H. E. Hayes, the director, and Mr. B. S. Pague, local forecast official and assistant director. There are now over eighty stations in the State having standard government instruments, and an especially noteworthy feature of the year's work has been the fitting out of the various colleges in the State with instruments, in order that the students may become familiar with the Weather Bureau work. The daily weather forecasts are widely disseminated by means of the telegraph, the telephone, the railroads, and the daily papers. Monthly bulletins have been issued since April, 1889, and in the growing season of each year weekly crop reports are issued. The assistant director has, during the year, addressed numerous farmers' institutes, and in this way the needs of the farmer are brought to the attention of the Weather Service, so that the latter is enabled to meet the demands of the agricultural interests.

* Journal of the Scottish Meteorological Society. Third Series. No. viii.

The present report contains full tabulation of the observations made at the stations during the year, besides papers on the Climate of Oregon, the Soils of Oregon, the Climate of Portland, etc. Owing to the influence of the ocean, that part of the State west of the Coast Range has a very equable and constant temperature, the extreme summer temperature being less than ninety degrees, and temperatures as low as ten degrees above zero are very unusual. East of the Coast Range a greater range of temperature is found, the maximum summer temperature in the valleys between the Coast and Cascade Ranges ranging between 75° and 90°. In winter the extreme temperature may reach 10° or 15° below zero in the great plains and valleys to the east of the Cascade Mountains, but the cold is of comparatively short duration. The highest temperature on record was noted on July 23, 1891, when the thermometer stood 102° at Portland, 100° to 105° in the Willamette Valley, and 103° to 108° in the Rogue River Valley. Severe storms, such as tornadoes, are unknown, and thunderstorms are very infrequent and never severe. This exemption is due, according to the report, to the equable thermal conditions, for without great and sudden changes of temperature no severe disturbances are possible. The prevailing direction of the wind from October to April is from the southern quadrant; from April to October, from the northern quadrant.

Vertical Decrease of Temperature on the Eiffel Tower. — In *Ciel et Terre* for March 1, 1893, M. Angot, chief of the Central Meteorological Bureau of France, has a short article on the vertical decrease of temperature as registered at different heights on the Eiffel Tower in Paris. In this investigation three Richard thermographs were used, placed at heights of 123, 197, and 302 meters, respectively, above the ground. The instrument at Parc Saint-Maur, with which the records from the Eiffel Tower were compared, was at two meters above the surface. The following table gives the mean temperatures for each month obtained from the years 1890-91, for the hours between midnight and 4 A. M., and between noon and 4 P. M. at three different heights above the earth's surface. The temperatures are in degrees Centigrade.

BETWEEN MIDNIGHT AND 4 A. M.

MONTH.	2 METERS.	123 METERS.	197 METERS.	302 METERS.
	Degrees.	Degrees.	Degrees.	Degrees.
January	1.37	2.05	1.98	1.59
February	0.35	1.48	1.75	1.59
March	3.90	4.50	4.59	3.80
April	5.40	5.89	5.78	5.23
May	9.63	10.39	10.33	9.65
June	12.09	13.22	13.32	12.40
July	13.30	14.02	14.02	13.13
August	12.97	13.97	14.19	13.41
September	11.71	13.79	14.29	13.77
October	8.07	9.61	10.22	9.66
November	4.25	4.68	4.66	4.24
December	— 0.30	0.27	0.27	— 0.02

BETWEEN NOON AND 4 P. M.

MONTH.	2 METERS.	123 METERS.	197 METERS.	302 METERS.
	Degrees.	Degrees.	Degrees.	Degrees.
January	4.79	4.07	3.47	2.74
February	5.91	4.49	3.90	3.28
March	9.53	7.95	7.19	6.35
April	12.21	10.44	9.63	8.83
May	16.95	15.38	14.37	13.60
June	20.16	18.33	17.39	16.62
July	20.22	18.76	17.75	17.02
August	20.64	19.24	18.40	17.60
September	20.11	18.98	18.17	17.25
October	14.20	13.28	12.55	11.55
November	7.71	6.77	6.26	5.38
December	2.96	2.19	1.83	1.04

During the night in all months the temperature increases at first as we ascend, passing a maximum at a mean height of 170 meters. The mean difference between this maximum temperature and the temperature at two meters above the surface is 1.1°. It is least in winter and spring (0. 7°) and greatest in autumn (2.1° in October and 2.6° in September). The following table gives the mean decrease of temperature during the day in every 100 meters between the surface and 160 meters, and between 160 meters and 302 meters above the surface.

MONTH.	BETWEEN THE SURFACE AND 160 METERS.	BETWEEN 160 METERS AND 302 METERS.
	Degrees.	Degrees.
January	0.65	0.73
February	1.09	0.64
March	1.24	0.86
April	1.37	0.85
May	1.32	0.89
June	1.46	0.87
July	1.25	0.87
August	1.15	0.86
September	0.97	0.94
October	0.82	0.96
November	0.75	0.80
December	0.60	0.68

The condition of instability is present in the atmosphere when the vertical decrease of temperature is more than 1° C. in 100 meters. This condition is present below the height of 160 meters from February to September, so that in all these months the lower parts of the atmosphere must have ascending currents during the day.

The Eiffel Tower has already been the means of giving us some valuable meteorological results, and none more so than the temperature records at different heights above the earth's surface.

The Tidal Wave of April 7 at Chicago. — The American readers of this JOURNAL will probably remember seeing some account in the newspapers of a so-called tidal wave, which occurred at Chicago on the morning of April 7. With regard to this phenomenon, which has been noted at Chicago from time to time in previous years, Dr. H. C. Frankenfield, Local Forecast Official at Chicago, sends the following explanation: —

"During April 6, the barometer fell steadily and rapidly until after midnight, through the influence of the storm advancing from the west. At 12.30 A. M., April 7, central time, the barometer suddenly rose .06 inch, and then resumed its fall, but not so rapidly as before. It was at the time of the sudden rise that the wave occurred, and it is evident that the former was the direct cause of the latter. While the barometer was falling during the day, the waters, both in the lake and in the river, being relieved from pressure, rose steadily. When the barometer made its sudden rise, increased pressure was of course as suddenly applied to the waters, and a rapid fall of the latter was the result. The waters of the lake, covering a very much larger area than those of the river, and being comparatively unconfined, were influenced much more quickly and fell to a lower level. The rapid adjustment of level which followed caused the outflow of an immense volume of water from the river, the height of the volume being greatly increased by its confinement within the narrow channel. When the barometer falls suddenly, the reverse action takes place, the water flowing from the lake into the river. During my residence in Chicago, there have been several of these waves, and in each case I have found that the time of the wave was coincident with that of a sudden and decided fluctuation of the barometer, as indicated by the recording barograph at the station, the size of the wave in each case being proportional to the amount of the change in the barometer. In the case described above, the wave was from four to six feet in height."

Meteorological Observations at Manila during 1891. — The meteorological observations made by the Jesuit Fathers at the Observatory of Manila have, since January, 1890, been published in monthly bulletins and the material thus accumulated furnishes a most valuable contribution to the meteorological literature of the world. The station itself is admirably situated, and the patient and careful work of the Jesuit Fathers has placed meteorologists generally under obligations to them. The bulletins include hourly records of pressure, temperature, absolute and relative humidity, direction and velocity of the wind, state of the sky, etc., as well as very full observations, magnetic observations. At the end of each monthly bulletin is a large chart, presenting graphically the variations of the different meteorological and magnetic elements during the month. These charts bring out very clearly the correlation and interdependence of the various weather elements, and such facts as the checking of the usual diurnal rise of temperature under the influence of clouds and rain, the diurnal variation of wind velocity, and the regular diurnal pressure curve are most strikingly shown. The charts of mean hourly pressures at Manila, compared with the irregular barograph curves at any of our stations, furnish striking illus-

tration of the regularity of tropical weather conditions, as differing from the irregularity of such conditions in temperate latitudes. The bulletins for May and September also contain charts of the seismic disturbances in the Philippine Archipelago during those months.

Report of the English Weather Service for 1891–92. — The annual Report of the Meteorological Council to the Royal Society for the year ending March 31, 1892, has recently been issued. The council consisted during 1891–92, of the following gentlemen: Lieut.-Gen. Richard Strachey, R. E., C. S. I., F. R. S., chairman; Mr. Alexander Buchan, M. A., LL. D., F. R. S. E.; Prof. George Howard Darwin, M. A., LL.D., F. R. S.; Mr. Francis Galton, M. A., F. R. S.; Mr. Edward J. Stone, M. A., F. R. S., and Capt. W. J. L. Wharton, R. N., F. R. S. Mr. Robert H. Scott, M. A., F. R. S., is the secretary, and Naval Lieutenant C. W. Baillie, R. N., F. R. A. S., the marine superintendent. The report contains a full account of the work done during the year. Forecasts are prepared three times a day, namely at 11 A. M., 3.30 P. M., and 8.30 P. M. The 3.30 P. M. forecast is employed for storm warnings only, the morning and evening forecasts being prepared for publication. The percentage of success attained during the year averages eighty, being highest for the south of England (eighty-four per cent), and lowest for the west of Scotland (seventy-five per cent). The total percentage of success was two lower than in 1890–91. Of the storm warnings issued during the year, 86.8 were justified, and 7.5 were not justified by subsequent weather, this being the lowest percentage of total failures on record.

Radiation and Absorption of Heat by Leaves. — In the April number of the *American Journal of Science*, Mr. A. G. Mayer has an article on the radiation and absorption of heat by leaves. The subject is an interesting one to the meteorologist, as well as to the botanist and the physicist, and the relation between the amount of radiant energy absorbed by day, and the amount lost by radiation at night furnishes an attractive field for study. In the investigation of Mr. Mayer, use was made of a highly sensitive thermopile in connection with a low-resistance, reflecting, astatic Thomson galvanometer, and considerable attention was given to the effect of dew upon the radiation of leaves. Mr. Mayer's results seem to show that if dark heat be allowed to pass through a leaf, rather more than eighty per cent is absorbed by the leaf, and somewhat less than twenty per cent transmitted. The absorption of heat by leaves is found to be highly selective. The effect of a covering of dew is to cut down the radiation from the leaves about one third. In this connection the writer says: "The surface of leaves being one of the best known radiators of heat, is, therefore, an equally good absorber of that heat. If, then, we imagine a forest in the tropics where the days and nights are of almost equal length the whole year round, very much of that heat which had been absorbed by the leaves during the day would be lost by radiation during the night, were it not for the fact that the blanket of dew which covers them cuts down this radiation to two thirds of its former value."

American Association of State Weather Services. — Bulletin No. 7 of the Weather Bureau is the report of the meeting of the American Association of State Weather Services, held at Rochester, N. Y., Aug. 15 and 16, 1892. In the October number of this JOURNAL, page 283, we gave a summary of the proceedings at that meeting, prepared by Mr. R. E. Kerkham, the secretary. One of the most important subjects considered was that of instrument shelters, and the report of the committee appointed to consider the subject of the "most suitable instrument shelter and manner of exposure to be generally adopted by State Weather Services," is of special interest. The committee consisted of Messrs. W. L. Moore, of Wisconsin; J. Warren Smith, of New England, and B. S. Pague, of Oregon. Messrs. Moore and Smith recommend the adoption of a modification of the design shown on page 22 of the "Instructions for Voluntary Observers"; that the inside back vertical measurements be twenty-six inches in the clear and the base a rectangle, twenty-six by eighteen inches; that it be exposed over sod, on ground as nearly level as possible, at an elevation of four and one-half feet for the bottom of the shelter, or about five and one-half feet for the pins supporting the thermometers. They further believe that the depth of three feet in the present standard shelter can be reduced to eighteen inches without impairing the accuracy of the readings. Mr. Pague believes that the bottom of the shelter should be seven and one-half feet above the ground. Mr. Smith and Mr. Pague recommend new forms of shelters, which are illustrated by drawings. The committee recommends that the several shelters be constructed and carefully tested at the central office of the Bureau.

CORRESPONDENCE.

A THEORY AS TO THE ORIGIN OF CYCLONES.

Editor of the American Meteorological Journal: —

Several weeks ago I saw in one of the New York periodicals a paragraph of a few lines stating that a French meteorologist had published an article in which he stated the theory that the earth was surrounded by rings of atmosphere, which probably gave to the earth as viewed from other planets, the appearance of having rings like Saturn, and that from these rings all cyclones had their origin.

The name of the author I do not remember, nor the name of the periodical in which his article was mentioned, but the few lines concerning his theory suggested that he had hit upon the same theory as to the origin of cyclones which I have entertained for several years. If it happens that our theories are alike, I desire to lay claim to priority of invention, since I conceived my theory fully five years ago. In the winter of 1888 and 1889, I wrote out my theory in a letter to an officer in my own corps; and over a year ago, while undergoing an examination for promotion, I wrote out the theory in much the same detail I give it here. That manuscript is on file in the Judge Advocate's office of the Navy Department, Washington, D. C.

Cyclones appear to be subject to fixed laws. These laws have been deduced from many observations, and they have been verified by the experience of vessels or localities exposed to them. These laws give rise to the various characteristics that cyclones exhibit, such as apparent place of origin, motion, size, velocity, and the like.

Since these characteristics are constant in all cyclones, we must infer that the causes which produce them must be equally constant. The question then arises, Where are we to look for these causes?

We know that many of the characteristics of cyclones bear a close and constant relationship with the trade-winds. Thus they have their *origin in the centre of the trade-wind zone. The latitude of their origin varies with the changes of this centre in following the sun's declination. They are most common in their origin where the trade-wind zones impinge on the eastern shores of the continents and large archipelagoes, and they are not known to originate between the trade-wind zones; that is, on the equator, or in latitudes north or south of these zones.* This is sufficient to convince us that the trade-winds have much to do in the formation of cyclones, if they are not, together with intimately associated winds, the only cause.

But the trade-winds are only part of a much greater system of atmospheric movement. The trade-winds being heated as fast as they reach the equatorial regions, rise to high altitudes, then flow toward the poles again, giving

us the anti-trade winds. These anti-trades, on reaching the polar limits of the trade-winds, become cooler; a portion continue on to higher latitudes, while the remainder sink to the earth's surface, are taken up with the flow toward the equator, and again become trade-winds.

Thus we see that north and south of the equator there are two huge coils of air formed by the trades and anti-trades, together with the ascending equatorial current and the descending current on the polar side. These coils prevail constantly over the large sea areas between 5° and 30° north and south. They extend east and west, probably over land areas as well, though mountain chains and conflicting local winds may throw them into confusion. They form around the earth two huge coils, resembling in shape and movement the rings of smoke sent into the air by the puffing of a locomotive. They might be appropriately termed *trade-coils*. They are parallel with the equator, and advance a little north or south of this line in following the sun's declination. Their thickness, that is, vertical height above the earth's surface, cannot be definitely stated. According to Piazzi Smyth, it is at an average height of nine thousand vertical feet that the ascending equatorial air divides into the anti-trades. The same writer, in his work on Teneriffe, also mentions having observed the trades contending with the anti-trades at an elevation of three thousand feet. Another authority mentions seeing the same thing at a much higher elevation, on the volcanic mountains of the Hawaiian Islands. I myself have seen for several days at a time the trade-winds driving clouds high about the top of Mauna Loa, which is fourteen thousand feet above the sea. Reclus says that the atmosphere heated at the equator rises to *several miles* in height, then turns to the north and south, forming the anti-trades. The latter is more likely an approach to the truth.

The velocity of the winds in the trade-coils can only be guessed. We know the average velocity of the trade-winds at the earth's surface, and the anti-trades must, at least, have the same velocity to counterbalance. But we must take into consideration the fact that at high altitudes winds move with much greater velocity than when close to, or in contact with, the earth's surface. For this reason the core of the trade coil might, under certain conditions, attain a velocity as violent as that of the new-born cyclone.

The trade-winds have considerable westerly element, following a curve toward the equator and toward the west. The anti-trades follow a curve symmetrical with that of the trades, extending away from the equator and likewise to the west. The curve of the latter is similar to the curve of a cyclone's trajectory. The westings of the trades and anti-trades give to the trade coil a westerly motion.

Now, we believe that all cyclones have their origin in this trade coil. How this occurs is the difficulty in displaying our theory. However, let us picture to ourselves the trade coils. The trades and anti-trades have been flowing for days, undisturbed. The ascending currents at the equatorial region and the descending currents at the polar side rise and fall with compensating regularity. The core of the coil, undisturbed by friction and whirled around by the surrounding trades, acquires great velocity, and

assumes by its velocity the integrity of a meteor. This velocity grows so great and uniform that it becomes inherent, and is in a large degree superior to the force of gravitation.

Let us believe now that some combination of forces disturbs the trade coil in such a way that a portion of it is broken out. The axis of the fragment is raised from the horizontal to a perpendicular, its western end being thrown up, while what was the eastern end is pointed toward, or in contact with, the earth, and we have a cyclone full grown and ready to leap along its trajectory.

Continents and archipelagoes, with their mountain ranges, local opposing winds, and large volumes of heated air, are sufficient to affect these great changes in the trade coils. What makes the theory appear the more plausible is the fact that just a little to the westward of all points where cyclones are born we always find just such a combination of circumstances.

G. A. LUNG,
Passed Assistant Surgeon, U. S. Navy.

U. S. R. S. MINNESOTA, NEW YORK, April 24, 1893.

THUNDERSTORMS, AURORAS, AND SUNSPOTS.

Editor of the American Meteorological Journal: —

I should not perhaps allow the review of my paper on Thunderstorms in the JOURNAL for April to pass without some comment at least. It is there admitted that there is "scarcely room for doubt that there is a periodicity in the aurora corresponding to a solar rotation." This admission involves another from which there is no escape, namely, that whatever it is in the sun that produces the aurora is able to have this effect at a certain angle only, otherwise there could be no recurrence in the manner which actually appears. This being the case, it remains simply to find out during what part of each revolution the auroral effect is propagated earthward, or, in other words, at what angle from the earth the originating solar disturbance is situated at such times. This involves nothing more than simply looking at the sun and keeping a record whenever there is an aurora. If this be done, it will soon be found that areas frequented by spots and faculæ are invariably at the eastern limb, and the recurrences at the interval of a synodic revolution depend upon the persistence and extent of such disturbances in particular localities. So far as the writer is able to determine, this rule is invariable, and it makes no difference what month or year is selected so long as an aurora is actually recorded to begin with. The only exceptions encountered have been apparent and not real, depending upon the fact that at some one of a series of returns, for example, the originating disturbance has been temporarily free from spots. Thus, in January, 1886, there was a violent magnetic storm from the 6th to the 10th, when a disturbed area containing faculæ only was coming into view, which area when at the meridian a few days later became the seat of many spots, several of which were very

large. It is noteworthy that this eruption of spots at the meridian was not attended by any magnetic or auroral outbreak whatever. Recently, Prof. Ricco has made a tabular exhibit of the condition of the sun with reference especially to the location of spots at the meridian at the times of the great magnetic storms of 1892, which were eleven in number. In not a single instance was there a spot group on the meridian at the times of these magnetic perturbations, and in only seven out of the eleven cases were spot groups anywhere in that vicinity, being distant such a space as would require from twenty-one to fifty-one hours to pass over. On the other hand, on the very dates of these magnetic storms and while the perturbations were actually in progress, without any retardation or variability of retardation, or any exception whatever, there were disturbed areas at the eastern limb containing spot groups, several of which made a record at many successive returns.

Thus far all is plain and easy; but if such a record of solar conditions be kept it will be found that the presence of disturbance at the eastern limb does not necessitate the appearance of the aurora, so that although we always find the disturbance when the aurora appears we cannot reverse the process, and always find the aurora when the disturbance appears. In this latter case it is found, as a matter of fact, no matter what the explanation may be, that there is as a rule substitution of thunderstorms. This is most striking in winter, when such storms are most unseasonable in this latitude. It has been the case throughout the past few months to a notable degree, such storms having become at times widespread and severe on the very dates on which auroras might have been expected in conformity with the statements above made. An earnest effort is being made to discover the explanation of this, and, as is announced tentatively in the Thunderstorm paper, it appears to depend upon the location in latitude of the originating solar disturbance. Thus, if at this season of the year, when the earth is opposite the sun's southern hemisphere, a solar disturbance appears at the eastern limb in the northern hemisphere, thunderstorms instead of auroras follow, and *vice versa*. For the purpose of adequate study, the Greenwich records of the positions of spots and faculæ are in process of reduction so that the eastern limb position may be found accurately and its time likewise determined in the case of every disturbance recorded This is a work of some magnitude, and not until it has been completed will it be possible to make as complete comparisons with thunderstorm and auroral records at all seasons and under all conditions as may be desirable. It is evident, however, as far as the work has progressed, that the leading features have been correctly outlined in the Thunderstorm pamphlet and others of like tenor.

M. A. VEEDER.

LYONS, N. Y., April 16, 1893.

BIBLIOGRAPHICAL NOTES.

CLOUD MEASUREMENTS AT BLUE HILL OBSERVATORY.

H. H. CLAYTON AND S. P. FERGUSSON. *Measurements of Cloud Heights and Velocities. From observations made at the Blue Hill Meteorological Observatory under the direction of A. Lawrence Rotch,* A. M. Annals of the Astronomical Observatory of Harvard College, Cambridge, Mass., 1892. Vol. XXX., part iii., pp. 205–268, plate I.

The introduction to this report, written by Mr. Clayton, tells us that systematic cloud observations have been carried on at the Blue Hill Observatory for five years. Four methods have been used in determining cloud heights. The base of very low clouds was determined by walking down the hill, whose summit is 126 meters above the surrounding lowland, until the under surface of the cloud was encountered. The angular elevation of the patches of light on cloud layers at night above the electric lights of neighboring cities often served to measure their altitude. Shadows of detached clouds were watched while passing over known points on the adjacent lowland; and by combining the actual velocity of the shadow and the angular velocity of the cloud, its height is deduced. Simultaneous triangulation with theodolites like those used at Upsala was carried on from two stations, 1,178 meters apart and connected by telephone. One of the theodolites and a plotting machine for the reduction of observations are illustrated in the frontispiece.

The accuracy of the several methods of measurement is carefully investigated. The error by triangulation averages only two or three per cent of the height; by altitude of bright patches over cities at night, the error is much greater. The propable error in velocities is somewhat more than in heights; but it is within reasonable limits.

One of the most instructive chapters in the report concerns cloud nomenclature. The system of Hildebrandsson and Abercromby is adopted, but only after a careful comparison of all other systems. The comparisons drawn between different cloud names illustrate at once the difficulty that must embarrass any one who attempts to discuss observations made by others than himself, and at the same time supplies the most comprehensive series of definitions, by which the records of one system may be translated into another. These comparisons are made after a familiarity with the definitions employed in our Weather Bureau, after examination of various cloud atlases, especially the Hildebrandsson-Koeppen-Neumayer photographic atlas; after studying a large collection of cloud photographs gathered in different parts of Europe by Mr. Rotch and there named by experts; after personal conference with Hildebrandsson during the International Meteorological Congress at

Munich in 1891, with Vettin at Berlin, and with observers at Upsala and at Kew. There is therefore probably no one in this country who has so broad an experience in the observation and naming of clouds as Mr. Clayton; and we hope that his experience may be preserved to us by the preparation of an atlas of cloud photographs for the guidance of American observers in this difficult field. The following table gives Clayton's condensed definitions of cloud names, after Abercromby and Hildebrandsson:

Cirrus (C). Thin, fibrous, detached, feather-like clouds.

Cirro-stratus (CS). Thin, white veil, more or less fibrous.

Cirro-cumulus (CK). Small, white, cottony balls in flocks. Flocks of small, detached, fleecy clouds.

Alto-cumulus (AK). Large, more or less rounded balls, flat discs, or rolls of fleecy clouds in flocks. White, except here and there a dark shading.

Alto-stratus (AS). A gray or blue veil, through which the sun and moon are faintly visible.

Strato-cumulus (SK). Large gray balls or rolls in close contact.

Cumulus (K). Piled clouds, with conical or hemispherical tops and flat bases.

Fracto-cumulus. Flat, broken clouds of the cumulus type.

Cumulo-nimbus (KN). Massive clouds from which showers fall.

Nimbus (N). A dense, dark sheet of ragged cloud from which rain or snow usually falls.

Stratus (S). Elevated fog floating in the air (Hildebrandsson). A thin, uniform layer of cloud at a very low level; detached, flat, structureless clouds (Abercromby).

The discussion of the results of the tables and reductions is a valuable addition to our knowledge of clouds in this country. Indeed, it has no predecessor that needs to be named in connection with it.

Clouds of the same kind are found to be lower in winter than in summer, although the base of the cumulo-nimbus forms an exception to this rule. Moreover, the diminution of winter height is of about the same proportion in the higher as in the lower clouds; hence, the decrease of actual height in winter is more marked in the upper than in the lower clouds. Cumulus clouds are shown to form at a greater height at noon (1,777 meters) than in the morning (1,439) or early evening (1,513). The base of these clouds is highest in spring (1,496 meters), decreases in summer (1,489) and autumn (1,412), and is least in winter (1,286); but their velocity is greatest in winter and least in summer.

The loftiest cirrus clouds at Blue Hill were found at 14,930 meters; 13,376 at Upsala, and 13,664 at Kew, or somewhat less than ten miles at the highest.

The mean cloud velocities indicate that the entire atmosphere from the lowest to the highest cloud level moves almost twice as fast in winter as in summer. The mean velocity of the highest clouds in winter is over 50 meters per second, or 100 miles an hour; and the highest velocity, 103 meters per second, or 230 miles an hour, shows that the upper currents sometimes flow with enormous velocities. A consideration of Vettin's results at Berlin, gained by the fading illumination of clouds at sunset, leads Clayton to the statement that the mean annual velocity of the cirrus over northern Ger-

many is 21.3 m. p. s.; while in this part of our country it is 35.9. The lower clouds of the two regions do not differ greatly in velocity. It is found that clouds of the cirro-cumulus type, that is, clouds which move in flocks, have a greater velocity than clouds of the cirro-stratus type at the same or even at a somewhat greater height. This is true all the year, but is more marked in winter. I infer that the reason for this will be found when the different kinds of clouds are studied with reference to the cyclonic centres about which they are formed; for the cyclonic circulation may at one part accelerate and at another part retard the general movement of the atmosphere in which it is developed.

The prevailing direction of cloud movement at all heights and in all seasons is from a westerly point. Indeed, above the level characterized by the alto-cumulus clouds (4,000 meters), the drift is scarcely ever from any other point. There is an important difference between the surface winds at Blue Hill and the drift of the cirrus clouds. The winds have a northerly or northwesterly source in winter; but the cirrus clouds drift from these points in summer. The midway levels of cumulus and alto-cumulus clouds depart little from an average northwest source both in summer and winter. Hildebrandsson has found just the opposite relation between the surface winds and the cirrus clouds in Europe; the winds being southwesterly and the cirrus more northerly in winter. This is well explained by the distribution of temperatures over continental areas; the surface winds tending to flow obliquely out from cold areas and obliquely inward towards warm areas, while the upper currents drift in compensating courses. The cirrus tend to move around areas of high temperature in the same order as the surface winds blow around areas of high pressure.

It is gratifying to know that Mr. Clayton is at present engaged in a discussion of the Blue Hill cloud observations with reference to cyclones and anti-cyclones. We may count on as careful work in this important subject as appears in the volume before us; we shall therefore expect results that will give critical indication of the behavior of the higher clouds over low and high pressure areas, and thus aid in the interesting discussion now in progress among meteorologists regarding the causes of the secondary atmospheric movements. W. M. D.

TITLES OF RECENT PUBLICATIONS.

BADEN. CENTRALBUREAU FUER METEOROLOGIE UND HYDROGRAPHIE. *Niederschlagsbeobachtungen der meteorologischen Stationen im Grossherzogthum Baden.* Jahrgang 1892. 2. Halbjahr. 4to. Karlsruhe, 1892. 25 pp.

LANCASTER, A. *Le climat de la Belgique en* 1892. 12mo. Bruxelles, 1893. 159 pp. 2 pl.

LEYST, DR. E. *Untersuchungen ueber die Bodentemperatur in Königsberg in Pr.* Excerpt: Schriften phys.-ökonom. Ges., Königsberg, xxxiii., 1892. 67 pp. 2 pl.

LONDON. METEOROLOGICAL OFFICE. *Report of the Meteorological Council to the Royal Society for the year ending 31st of March*, 1892. 8vo. Lond., 1893. 111 pp.

QUEENSLAND. CHIEF WEATHER BUREAU. *Meteorological report for* 1888, 1889, 1890, *and* 1891. By Clement L. Wragge, Government Meteorologist. Fol. Brisbane, 1892. 4 pp. 3 ch.

ST. PETERSBURG. PHYSICAL-CENTRAL-OBSERVATORY. *Monthly meteorological bulletin, No. 1, January,* 1893 (Russian text.) Fol. St. Petersburg, 1893. 8 pp. 1 map.

UCCLE. *Observations météorologiques d'Uccle, Jan.-Août,* 1892. (Monthly.) Annales de l'Observatoire Royal de Belgique. Fol. Bruxelles, 1892.

U. S. WEATHER BUREAU. *Anemometry. A circular of general information respecting the theory and operation of typical instruments for indicating, measuring, and automatically recording wind movement and direction, with detailed instructions for the erection and care of these instruments of the Weather Bureau pattern.* Circular D. Instrument Room. Prepared by Prof. C. F. Marvin. 8vo. Wash., 1893. 40 pp.

PUBLICATIONS RECEIVED.

ABBE, C. "The Mechanics of the Earth's Atmosphere," a collection of translations. Smithsonian Miscellaneous Collections, Washington, 1891. 8vo, pp. 324. (This is a valuable collection of translations of papers by Hagen, Helmholtz, Oberbeck. Hertz, and Von Bezold, on the "Mechanics of the Earth's Atmosphere," all of which are of great importance to students of the higher mathematical and physical meteorology. Prof. Abbe has done a great service to all English-speaking students of this subject in giving them these translations, although they are quite beyond the understanding of the majority of readers.)

FERNANDEZ, VICENTE. "Las Estrellas Fugaces de 23 de Noviembre de 1892." From: Memorias de la Sociedad Scientifica, "Antonio Alzate." Mexico, 1893. 8vo, pp. 159-162.

FRITSCHE, H. "Ueber die Bestimmung der geographischen Laenge und Breite und der drei Elemente des Erdmagnetismus durch Beobachtung zu Lande." St. Petersburg, 1893. 8vo, pp. 109, pl. VI.

INDIA. Meteorological Department of the Government. Monthly Weather Review for July and August, 1892. By John Eliot, M. A., Meteorological Reporter to the Government of India. Calcutta, 1892. Fol., pp. 245-327, pl. X.

LONDON. Report of the Meteorological Council to the Royal Society for the year ending March 31, 1892. London, 1893. 8vo, pp. 111.

MANILA. Observatorio Meteorologico. Observaciones verificadas durante Enero-Deciembre, 1891, Bajo la Direccion de los PP. de la Compania de Jesus. Manila, 1892. Fol.

OREGON WEATHER BUREAU. Second Biennial Report. By H. E. Hayes, Director, and B. S. Pague, Local Forecast Official, Assistant Director, Salem, 1893. 8vo, pp. 249.

ODESSA. "Meteorologische Beobachtungen," Meteorologisches Observatorium der Neurussischen Universitaet, Januar-Dezember, 1892. Odessa, 1892-93.

SAXONY. "Ergebnisse der Meteorologischen Beobachtungen im Koenigreich Sachsen im Jahre 1891." Abtheilungen I., II., III., des Jahrbuches des K. Saechsischen Meteorologischen Institutes. IX., Jahrgang, 1891. Chemnitz, 1892. 4to, pp. 1-128, 1-94, pl. X.

U. S. WEATHER BUREAU. Report of the First Annual Meeting of the American Association of State Weather Services, co-operating with the Weather Bureau, U. S. Department of Agriculture. U. S. Weather Bureau Bulletin, No. 7. Washington, 1893. 8vo, pp. 49.

VEEDER, M. A. "Solar Electro Magnetic Induction." Reprint from Astronomy and Astro-Physics," No. 113. 8vo, pp. 3.